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First Data on Lake Level Changes in Northeastern Siberia during the Postglacial Time

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Moraines of the Tyellakh Group [1] (QIII₂₋₄) preserved in river valleys of the northeastern Kolyma River basin indicate development of cirque–valley glaciers originating in the Kilgan Mountains located at the northeastern periphery of the Kolyma Ridge that separates drainage basins of the Sea of Okhotsk and Kolyma River. Moraines host lakes with a length of up to 1–5 km and a relatively small width depending on the valley bottom dimension. The study of lacustrine sediments, their bed-by-bed palynological analysis, and radiocarbon dating provided the first information on lake levels during the final glacial stage of the Late Pleistocene, as well as the Pleistocene–Holocene boundary and Holocene, for the upper reaches of the Kolyma River.

Sediments were sampled using a piston corer from glacial Lake Engteri (61°10'32" N, 153°53'20" E) located in upper reaches of Ozernyi Creek, a left tributary of the Dzhugadzhaka River (the Kolyma River basin) (Fig. 1). The lake is 1300 m long and 200 m wide. The corer recovered a 265-cm-thick section from the depth of 1014 cm in the central part of the lake (Hole 1). The upper part of the section is composed of gray horizontally bedded silts with fine organic matter dissemination. The lower interval (185–265 cm) is composed of light bluish gray varved clay with an admixture of sand and gravel. The pollen diagram compiled for lacustrine sediments using the TILIA software package demonstrates the share of each pollen and spore taxon in palynological spectra. The diagram includes five

zones recording a general trend of climate changes in northeastern Siberia [2]. Herbaceous pollen zone (EN1), which characterizes varved clays, reflects the mosaic distribution of plant communities of mountainous tundra that dominated in the terminal Late Pleistocene (Sartanian epoch, oxygen isotope stage 2). They range from the discrete cover of wormwood, Siberian *Selaginella*, and various herbs on dry rocky slopes to wet and moderately wet sedge and sedge–gramineous vegetation on valley bottoms and low slopes. The sharp increase in proportion of *Betula* pollen in Zone EN2 undoubtedly indicates a substantial reorganization in plant cover induced by warming. A similar zone, termed as the birch zone, has been identified in most of the lacustrine palynological records of northeastern Siberia [3] and points to the distribution of birch tundra. The lower boundary of the zone is dated at 12 400 yr ago. Taking this into consideration, the sedimentation rate in Lake Engteri is estimated at 0.17 mm/yr, which corresponds to the average sedimentation rate in other glacial lakes of the region.

The wide distribution of large shrub communities of alder and birch recorded in palynological spectra of Zone EN3 should be related to the pre-Boreal and Boreal periods of the Holocene (10 200–8000 yr ago). The persistent occurrence of *Larix* pollen in spectra from this zone definitely points to development of larch forests with Japanese stone pine (*Pinus pumila*), which is gradually becoming an important element of larch forests. The upper boundary of Zone EN3 corresponds to the first (after the Sartanian cooling) *Pinus* pollen maximum (Fig. 2), which approximately coincides with the boundary between the Boreal and Atlantic periods of the Holocene [4]. Palynological Zone EN5 characterized by spectra with a maximal *Pinus* pollen content probably reflects the extension of the Japanese stone pine belt in mountains and the lowering of the upper boundary of the larch forest during the Subboreal and Subatlantic periods of the Holocene.

Sediments sampled 200 m away from the southwestern lakeshore at a depth of 688 cm (Hole 2) have a different lithology. The complete thickness of sediments is 376 cm; i.e., the base of Hole 2 is located 215 cm below that of Hole 1. The upper part (0–145 cm) is composed of gray lacustrine silt with remains of aqueous plants. These sediments are underlain by silt with an admixture of sand and gravel, interbeds of inequigranular sand (sometimes inclined at 3°–10°), and lake peat. The sand and gravel content increases in the 220–350 cm interval. Such composition of sediments and abundant remains of aqueous plants dwelling in shoals indicate accumulation of sediments close to the shore and intense influx of clastic material from the coast. It should be noted that the silty layer with sand and

gravel at the base of Hole 2 (350–376 cm) contains spore–pollen spectra identical to spectra from the “birch pollen zone” (EN2) in Hole 1. The upper layers include the succession of all zones outlined in Hole 1. Thus, the difference in altitude between the birch zone in Holes 1 and 2 indicates that the glacial lake depth did not exceed 1.5–2.0 m approximately 12 400 yr ago; i.e., its level was about 10 m lower as compared with the present-day one. A small lake likely extended in the northeastern direction toward the locality where the present-day depth is maximal (20 m). Postglacial warming reflected in spectra of Zone EN2 was accompanied by an increase in atmospheric precipitation, melting of the Late Quaternary mountainous glacier, and gradual rise of lake level. Based on the radiocarbon dating of wood remains recovered from a depth of 325 cm in Hole 2 (CAMS103337, 9025 ± 35 yr), the initial sedimentation rate was 0.15 mm/yr at the bottom of the core (376–325 cm). At the same time, several radiocarbon age estimates obtained for plant remains from Hole 2 (CAMS103336, depth 318 cm, 8785 ± 40 yr; CAMS103809, depth 233 cm, 8486 ± 40 yr; CAMS103335, depth 152 cm, 7460 ± 50 yr; CAMS103334, depth 138 cm, 7275 ± 35 yr) indicate significant changes in sedimentation rates of coastal facies. Their maximum value of 2.8 mm/yr is established for the interval of 318–233 cm mainly composed of sand and gravel. This is explained by the increase in summer atmospheric precipitation and intense melting of glaciers during the Boreal period of the Holocene and influx of coarser clastic material to Lake Engteri with melt waters. Taking into consideration the fact that sediments accumulated near the lakeshore, one can assume that the lake level rose by at least 3–4 m. In the Boreal–Atlantic boundary period of the Holocene, the influence of coastal facies was still relatively high, although the role of fine-grained lacustrine fractions (silt) substantially increased with the formation of lake peat beds and the sedimentation rate decreased to 0.79 mm/yr. This signifies an increase in the water surface of the lake. The lake level during this period could probably rise by not more than 2–3 m because relatively frequent sand intercalations in the 233–138 cm interval in Hole 2 point to an influx of clastic material from the nearby shore.

The lithological features of horizontally bedded silts in the upper lacustrine section in Hole 2 (145–0 cm) imply their formation relatively far from the lakeshore at a rate of 0.18 mm/yr, which is comparable to the average sedimentation rate in glacial lakes. As is evident from the radiocarbon age of 7275 ± 35 yr, silts accumulated mainly during the Atlantic period, which is considered the climatic optimum in the Holocene [5]. The lake level was highest at that time.

Signs of its highstand are recorded, for instance, by two shorelines that are preserved on moraine hills surrounding Lake Engteri in the northeast and, probably, by sediments that form a relatively wide hillocky surface between Lake Engteri and Lake Utinoe located 2.5 km southwest. The absence of forests at this surface suggests that it was composed of compact lacustrine sediments that prevent the development of root systems.

Thus, geomorphologic and botanic observations provide grounds to conclude that the studied lakes were connected during the Atlantic period of the Holocene and the level of the single (approximately 5-km-long) lake was 3–5 m above the present-day one. The rise in the lake level was probably related to the substantial increase in the atmospheric precipitation at that time, particularly during summer seasons (more than 700 mm/yr). During the Subboreal and Subatlantic periods, the lake level dropped to its present-day position.

ACKNOWLEDGMENTS

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Figure 1. Geographic location of Lake Engteri.

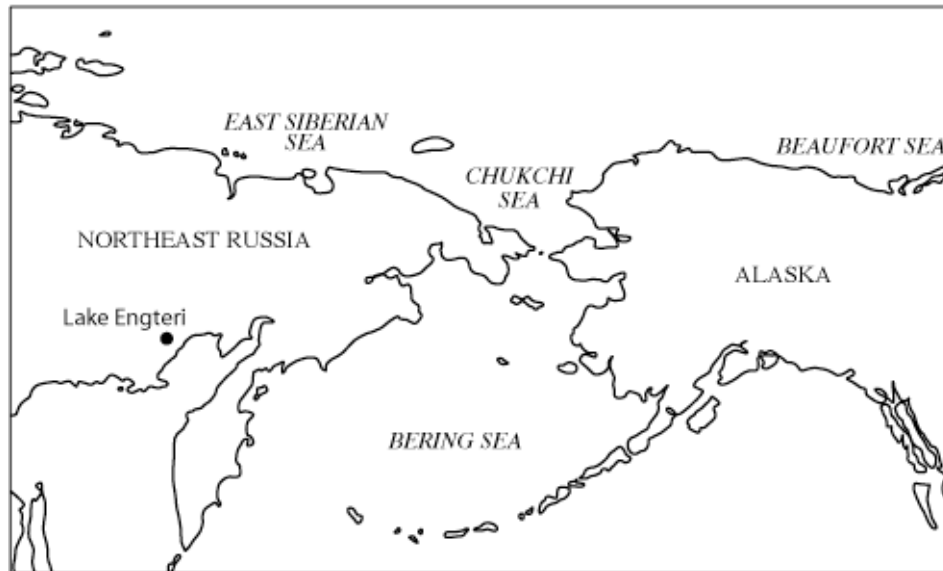


Figure 2. Proportions of plant groups and main spore–pollen taxa in spectra from sediments of Lake Engteri.

